

## Crustacea Copepoda : *Amphicrossus pacificus* gen. et sp. nov., an erebonasterid copepod (Poecilostomatoida) from the New Caledonian continental shelf

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### ABSTRACT

A new species of Erebonasteridae, *Amphicrossus pacificus*, is described on the basis of a single female from a depth of 155 m north of New Caledonia in the Grand Passage zone. The new species is closely related to *Erebonaster spinulosus* Humes and for that reason the latter is transferred to the new genus *Amphicrossus*. Differences in body ornamentation and armature of maxilla, maxilliped and P4 serve to distinguish *Amphicrossus* and *Erebonaster*. Other noticeable discrepancies are found in the structure of the rostrum, the shape of the thoracic epimera and the design of the fifth pair of legs. A peculiar structure, the "sensory area", is shown on the posterior surface of enp-2 P2 in both *Amphicrossus* species which can be differentiated from each other on the basis of differences in antemulatory setation, ornamentation of P1-P4 (exopods, intercoxal sclerites) and length:width ratio of anal somite and P5 exopod. The discovery of *A. pacificus* in the southern hemisphere considerably extends both the depth range and geographical range of the family.

### RÉSUMÉ

Crustacea Copepoda : *Amphicrossus pacificus* gen. et sp. nov., copépode de la famille des Erebonasteridae (Poecilostomatoida) provenant du plateau continental de la Nouvelle-Calédonie.

Une nouvelle espèce d'Erebonasteridae, *Amphicrossus pacificus*, est décrite d'après une seule femelle récoltée à 155 m de profondeur, au nord de la Nouvelle-Calédonie, dans la zone du Grand Passage. Cette espèce est très proche d'*Erebonaster spinulosus* Humes qui, pour cette raison, est transféré dans le nouveau genre *Amphicrossus*. Des différences dans l'ornementation du corps et l'armature des maxilles, maxillipèdes et quatrièmes périopodes permettent de distinguer

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*Amphicrossus d'Erebomaster*. D'autres caractères distinctifs sont fournis par la structure du rostre, la forme des épimères thoraciques et la conformation des cinquièmes pattes. Une structure particulière, l'aire sensorielle, se trouve sur la face postérieure de l'endopodite des deuxième péréiopodes chez les deux espèces d'*Amphicrossus*. Celles-ci peuvent être séparées par les soies antennulaires, l'ornementation des quatre premières paires de péréiopodes (exopodites et sclérites intercoaux), le rapport longueur/largeur du somite anal et l'exopodite des cinquièmes péréiopodes. La découverte d'*A. pacificus* dans l'hémisphère sud étend considérablement les répartitions bathymétrique et géographique de la famille.

## INTRODUCTION

In the last decade much attention has been paid to the copepod fauna of hydrothermal vent areas in the East Pacific and the Atlantic, and cold seeps in the Gulf of Mexico (HUMES, 1988). The exploration of these unusual habitats by means of manned deep-sea submersibles has produced a number of very distinctive copepod types of great phylogenetic significance. One of these represents the poecilostomatoid family Erebonasteridae currently embracing the type genus *Erebomaster* Humes, 1987 and *Centobnaster* Huys & Boxshall, 1990. The Erebonasteridae belongs among the most primitive poecilostomatoid copepods known thus far and can readily be distinguished from other families by the unique presence of a distinct palp on the mandible. The alleged presence of such a palp in the Mantridae (LEIGH-SHARPE, 1934) was corroborated by HUYS (1990) but the gnathostomous nature of the mouthparts indicates that *Mantra speciosa* Leigh-Sharpe should be allocated to the Cyclopoida rather than to the Poecilostomatoida, a relationship already hinted at by HUMES (1987). Similarly, DELAMARE DEBOUTTEVILLE & NUNES-RUIVO (1955) reported a vestigial mandibular palp in *Echiurophilus fizetii*. However, their "lobe externe de la mandibule" is drawn as an inner expansion of the limb and is directed into the oral chamber which is an unlikely position for a palp. The relative position of the various mouthparts in their Fig. 5 suggests that the authors have transposed the mandible and the maxillula. The limb indicated as "mx1" presumably represents the falcate mandible; the "external lobe" of the mandible might be the positional homologue of the maxillulular gnathobase.

The family Erebonasteridae at present contains three bathyal species. The vent species *Erebomaster protentipes* Humes, 1987 was found in 2000 m at the Guaymas Basin in the Gulf of California. *E. spinulosus* Humes, 1989 was described from a depth of 3266 m at cold seeps near the base of the West Florida Escarpment in the eastern Gulf of Mexico. Recently, HUYS & BOXSHALL (1990) reported on the discovery of a new genus and species, *Centobnaster humesi*, in the deep sea of New Caledonia. Inspection of copepod collections gathered during the French MUSORSTOM 4 expedition to New Caledonia revealed a fourth species of Erebonasteridae closely related to *E. spinulosus*.

## MATERIAL AND METHODS

The holotype was dissected in lactic acid and the dissected parts were placed in lactophenol mounting medium. Preparations were sealed with glyceel (Gurr®, BDH Chemicals Ltd, Poole, England).

All drawings have been prepared using a camera lucida on a Leitz Dialux 20 interference microscope. The terminology for the segmental composition of the mandible and maxilliped are followed according to BOXSHALL (1985: 341-345). The setae of the caudal rami are named and numbered as proposed by HUYS (1988). Abbreviations used in the text and figures are: P1 - P6, first to sixth pereopods; exp., exopod; enp., endopod; exp(enp)-1(-2, -3), to denote the proximal (middle, distal) segment of a ramus.

## SYSTEMATICS

### Family EREBONASTERIDAE Humes, 1987

REMARKS. — There are substantial differences between *E. protentipes* and *E. spinulosus* and the discovery of a third species of Erebonasteridae indicates that the genus *Erebomaster* unites species drawn from two different lineages. Some of these differences were already outlined by HUMES (1989: Table 1) who kept both species in the

same genus primarily on account of the unique possession of a distinct mandibular palp. In both *E. spinulosus* and the new species to be described below the body somites and caudal rami are highly ornamented with spinules and a similar rich ornamentation is found on the various segments of, for example, the antennula, the antenna and the maxilliped, and on the anterior face of the labrum. In *E. protentipes* the body surface is smooth and such a spinular armature is apparently missing from the appendages mentioned above. The somites bearing P2 to P4 are about equal in width in all three species but the respective epimera are distinctly expanded posteriorly in *E. protentipes* only. A noticeable difference is found in the rostrum which is smooth in the latter species whereas it is furnished with median denticles and lateral setules in both *E. spinulosus* and the new species. In *E. protentipes* the claw of the maxilla possesses a smooth concave margin and 2 setae; in the other two species this margin is furnished with an inner process and 1 seta only. Similarly the claw of the maxilliped is provided with a digitiform process near the distal seta in *E. spinulosus* as well as in the new species whereas such a process is absent in *E. protentipes*. Noticeable discrepancies are also found in the ornamentation of the P4 exopod, and particularly in the structure of the P5. In *E. protentipes* the latter limb extends to the anterior margin of the anal somite and has an exopod which is 3.6 times the length of the protopod; the terminal seta is shorter than the exopodal segment. In the other species the highly ornamented fifth leg does not extend to the posterior margin of the genital double somite and possesses an exopod which is at most twice the length of the protopod; the terminal long seta is more than 9 times as long as the exopod. A peculiar feature is the presence of a so-called "sensory area" on the posterior surface of enp-2 P2 in *E. spinulosus*. This area presumably consists of a (secretory ?) tube pore connected with underlying tissue. It is present in the new species but missing in *E. protentipes*. The foregoing suite of differentiating characters suggests that *E. spinulosus* should be removed from the genus *Erebonaster* Humes 1987 and transferred to a new genus *Amphicrossus* gen. nov.

#### Genus *AMPHICROSSUS* nov.

DIAGNOSIS. — Erebonasteridae. Body elongate, cephalosome not distinctly wider than fifth pedigerous somite. Body surface highly ornamented with spinules. Epimera of 2nd - 4th pedigerous somites not expanded posteriorly; somites equal in width. Urosome 5-segmented in female, comprising genital double somite without lateral processes and 3 abdominal somites. Caudal ramus with 5 or 6 setae (setae IV and V fused, seta I sometimes lost). Rostrum prominent, with median denticles and lateral setules. Antennula 6-segmented; segments heavily ornamented with spinules and setules; aesthetascs on segments III, VI and VII. Antenna with 3 setae on enp-2 and 6 setae/spines on enp-3. Labrum with blunt lateral teeth and median, rounded, spinulose process; anterior face spinulose. Gnathobase of mandible with specialised blades; palp with 4 setae. Maxillula without knob-like process. Maxilla with inner process and 1 seta on distal segment; outer margin of basal segment setulose. Maxilliped with heavily ornamented basis; claw with 2 setae and digitiform process. Enp-2 P2 with posterior sensory area. Exp-3 P4 with formula II.I.4. Fifth pair of legs lateral, not joined by intercoxal sclerite; not extending to posterior margin of genital double somite; exopod at most twice the length of protopod, with 4 setae.

TYPE SPECIES. — *A. spinulosus* (Humes, 1989) comb. nov.

OTHER SPECIES. — *A. pacificus* sp. nov.

ETYMOLOGY. — The generic name is derived from the Greek ἀμφί, meaning on both sides, and κροσσός, meaning fringe, and refers to the setulose ornamentation of the rostrum.

#### *Amphicrossus pacificus* sp. nov.

Fig. 1-8

MATERIAL EXAMINED. — New Caledonia. MUSORSTOM 4 : stn DW 149, 19°07.6' S, 163°22.7' E, Grand Passage, 155 m, Waren dredge, coarse and sandy bottom, 14 September 1985 : ♀ holotype dissected on 11 slides and deposited under N° MNHN-Cp 577 in the Muséum national d'Histoire naturelle, Paris.

DESCRIPTION. — Female (fig. 1-8). Antennules, antennae, P5 and caudal rami partly damaged. Body (fig. 1A, 2A) elongate, moderately flattened; comprising 5-segmented prosome and 5-segmented urosome. Body length 2260  $\mu\text{m}$  measured from tip of rostrum to posterior margin of caudal rami. Greatest width 600  $\mu\text{m}$  measured at posterior margin of first pedigerous somite. Greatest dorsoventral thickness of prosome 460  $\mu\text{m}$  measured at strongly produced area immediately posterior to maxillipeds. Body surface (including caudal rami) densely covered with irregular pattern of minute spinules. Ratio of length to maximum width of prosome 1.54:1. Ratio of length of prosome to length of urosome 0.89:1.

Rostrum (fig. 1C) prominent, non-articulating, with 2 sensillae, 1 median and 2 lateral pores; anterior margin bearing small denticles flanked by fringe of long setules on either side.

Somites bearing P1 to P4 almost equal in width; surface ornamentation consisting of diminutive spinules interspersed with secretory pores and tiny sensillae. Epimeral plates of pedigerous somites not expanded posteriorly; ventrolateral margins furnished with long setules (fig. 2B).

Urosome (fig. 5A) comprising fifth pedigerous somite, genital double somite and 3 free abdominal somites. Hind margin of pre-anal somites with row of tiny spinules. Somite bearing leg 5 (figs 1A; 2A; 5A) 190 x 510  $\mu\text{m}$ , much broader than long in dorsal aspect; without lateral processes and with fifth pair of legs arising laterally (fig. 2A). Genital double somite (fig. 5A) comprising fused genital and first abdominal somites; 470 x 335  $\mu\text{m}$  in dorsal aspect, slightly wider than long; roundly expanded in anterior half, narrowed in posterior half (width 310  $\mu\text{m}$ ); original segmentation not distinctly demarcated. Genital apertures visible in dorsal aspect (fig. 1A) tapering in posterior half; posteroventral and -lateral margins bearing minute spinules (fig. 1B). Anal operculum vestigial.

Caudal ramus (fig. 1B, 5A) elongate, 335 x 48  $\mu\text{m}$ , ratio of length to width 6.98:1; with 4 secretory pores and presumably 6 setae. Seta 1 absent; nature and length of other setae unknown but presumably similar to *A. spinulosus*.

Egg sac unknown.

Antennule (fig. 3A) slightly damaged; 6-segmented and 400  $\mu\text{m}$  long. First two segments larger than others. Second segment with blunt posterior process bearing long spinules. Lengths of segments (measured along anterior margin): 113  $\mu\text{m}$ , 129  $\mu\text{m}$ , 26  $\mu\text{m}$ , 32  $\mu\text{m}$ , 32  $\mu\text{m}$ , 68  $\mu\text{m}$ . Formula for armature (partly deduced from scars: see arrowheads): I-3; II-16; III-[2 + aesthetasc]; IV-2; V-[2 + aesthetasc]; VI-[6 + aesthetasc]. Aesthetascs jointed. Surface and margins of all segments heavily ornamented with spinules and setules. Segments IV-VI with posterior setae.

Antenna (fig. 5B-D) slightly damaged; 4-segmented, comprising undivided protopod (coxa and basis fused) and trimerous endopod; all segments heavily ornamented with spinules and setules as illustrated. Protopod with inner seta and with area of flexible membrane at articulation with endopod. Enp-1 with a mid-margin spine; enp-2 (fig. 5D) with 1 long and 2 short pinnate spines at inner subdistal angle; enp-3 (fig. 5C) with 2 pinnate setae subdistally and 4 curved (3 geniculate) distal setae increasing in length abaxially.

Labrum with numerous spinules and a median secretory pore on anterior surface (fig. 4A); distal margin with a rounded, median spinulose process and several blunt teeth bilaterally (fig. 3B).

Mandible (fig. 4B) with strong gnathobase and minute unisegmented palp. Gnathobase with a strong pinnate spine and three pectinate blades (dorsal blade with indistinct suture at the base). Palp emerging from foramen formed by lateral margin of labrum and anterior face of maxillula (fig. 4A); with bipinnate lateral seta and 3 bipinnate setae apically and projecting beyond edge of cephalosome.

Maxillula (fig. 3C) with armature consisting of an outer group with 1 smooth and 2 pinnate setae, an inner group of 2 small spines, and an inner patch of tiny spinules; outer margin with patch of long setules.

Paragnaths slightly developed spinulose lobes, separated.

Maxilla (fig. 3D) two-segmented; first segment large with area of flexible membrane around basal articulation and with distal endite consisting of a smooth seta, outer margin with long setules; second segment produced into strong claw with one outer proximal seta and concave margin having spinous protuberance and more distally several minute spinules.

Maxilliped (fig. 4C, D) comprising syncoxa, basis and 2-segmented endopod. Syncoxa with two inner setae; basis with spinular ornamentation as illustrated, 1 long seta on posterior surface and 1 short seta on anterior

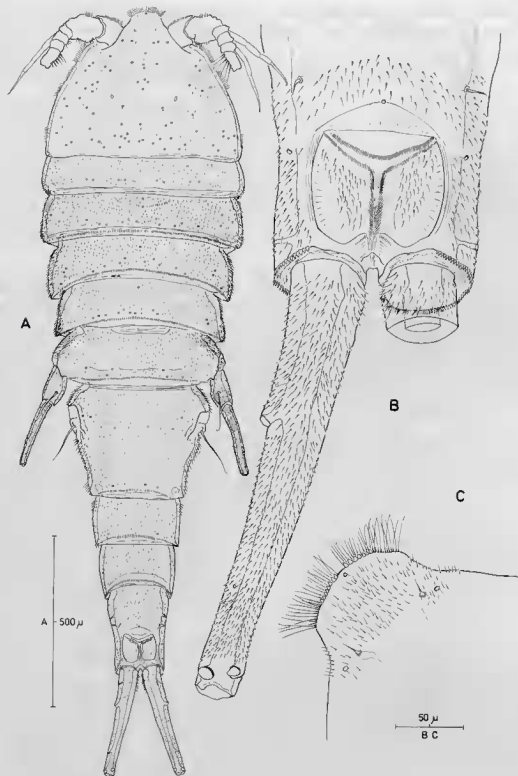


FIG. 1. — *Amphicrossus pacificus* sp. nov. : A, Habitus of female, dorsal view; B, Anal somite and left caudal ramus, dorsal view; C, Rostrum, dorsal view.

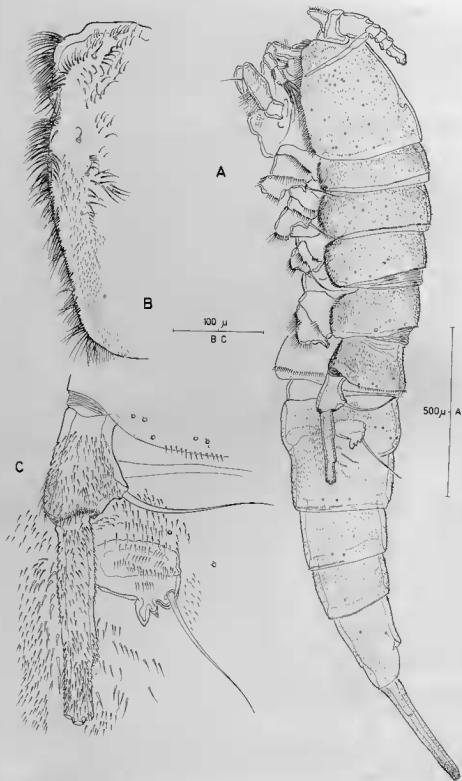


FIG. 2. — *Amphicrossus pacificus* sp. nov.: A, Habitus of female, lateral view; B, Ventral margin of second pleurotergite; C, P6 and gonopore, lateral view.

surface. Enp-1 without setae but with several spinules; enp-2 produced into robust, distally recurved, blunt claw (fig. 4E) bearing secondary digitiform process on inner margin, 1 seta on anterior surface and another seta on posterior surface.

Swimming legs 1 to 4 (fig. 6A-B; 7A-B; 8A) biramous, with 3-segmented rami and protopods. Armature formula as follows (Roman numerals indicating spines, Arabic numerals indicating setae) :

	Coxa	Basis	Endopod	Exopod
Leg 1	0 - 1	1 - 1	0 - I; 0 - I; I, II, 3	1 - 0; 1 - 1; III, I, 4
Leg 2	0 - 1	1 - 0	0 - I; 0 - 2; I, II, 3	1 - 0; 1 - 1; III, I, 5
Leg 3	0 - 1	1 - 0	0 - I; 0 - 2; I, II, I2	1 - 0; 1 - 1; III, I, 5
Leg 4	0 - 1	1 - 0	0 - I; 0 - 2; I, II, II	1 - 0; 1 - 1; II, I, 4

Præcoxae represented by sclerite with coarse (P1) or tiny (P2-P4) spinules along the distal margin. Coxae with inner plumose seta. Basis of leg 1 with outer seta and inner spine (fig. 6B) 98 µm long, finely pectinate along the outer margin and bifid at the tip. Distalmost seta on enp-3 P1 distinctly longer than other setae. P2 with posterior surface of enp-2 showing sensory area with tube pore (fig. 6C). Ornamentation of legs 1-4 as illustrated. Exopod segments (exp-1 in P2-P2; exp-(1-3) in P3-P4) and enp-1 (P4) also with spinules/ setules on posterior surface. All bases with spinules at margin between rami, and with two spinular patches in inner half of anterior surface. Basis of legs with bipinnate seta at outer margin near junction with coxa. Distal inner spine of enp-3 P3-P4 plumose in proximal half, serrate in distal half. Intercoxal sclerites well developed, much wider than high, with concave ventral margin; unarmed in P4, with spinules on either lateral side in P1, with lateral and median setules in P2-P3.

Fifth pair of legs damaged, located at lateral hind margin of fifth pedigerous somite (fig. 1A; 2A, C); members not joined by intercoxal sclerite as in legs 1-4. P5 2-segmented, uniramous; comprising undivided protopod and 1-segmented exopod (fig. 2C). Both segments densely covered with minute spinules on the anterior surface; protopod with an outer mid-margin, minutely pinnate seta (175 µm; derived from basis). Exopod 5.8 times as long as wide (38 x 220 µm) with 1 spine at the outer margin and 3 elements at the distal margin.

Copulatory pores (fig. 6D) small, paired; located in common, midventral depression in anterior half of genital double somite (fig. 5A); no external connection with lateral genital apertures; each copulatory pore opening into heavily sclerotized duct leading to lateral seminal receptacle; secretory pore on either side of midventral depression. Genital apertures migrated to dorsolateral position (fig. 2C). Each gonopore covered by operculum derived from P6; armature consisting of long smooth seta (160 µm) and small, spinous, bifid process (fig. 2C).

Colour of living specimens unknown.

Male unknown.

ETYMOLOGY. — The species name alludes to the Pacific where the species was collected.

REMARKS. — *Amphicrossus pacificus* can be differentiated from its only congener *A. spinulosus* on the basis of a number of characters summarized in Table 1. Additional differences are found in the general body facies such as the shape of the pleurotergites of the pedigerous somites (P2-P4) which are distinctly produced laterally in *A. spinulosus* so that the maximum width is measured at the P3-bearing somite whereas in the new species the thoracic somites are not considerably wider than the cephalosome. In *A. pacificus* the body is gradually tapering posteriorly, however, in HUMES' species there is a distinct separation between the prosome and urosome caused by the big difference in width between the P4- and P5-bearing somites. Slight differences are also found in the shape of the rostrum and of the process on the maxillary claw and the proportional lengths of the various antennular segments. In general, *A. pacificus* shows a richer ornamentation on the various appendages and limbs.

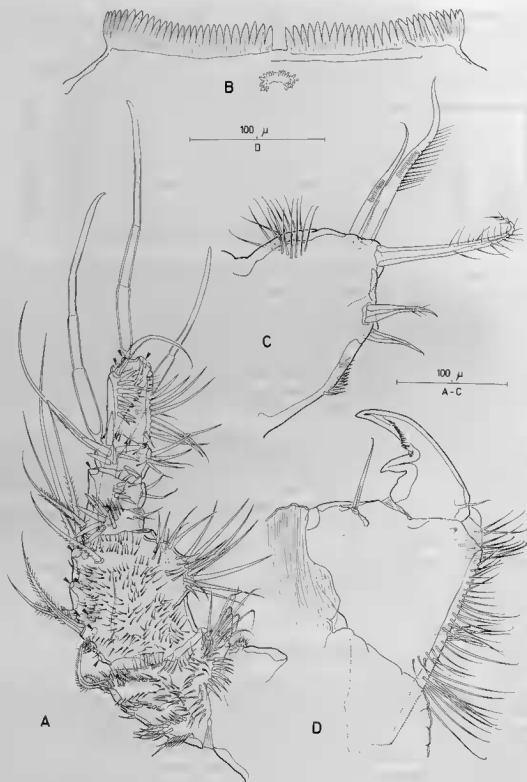


FIG. 3. — *Amphicrossus pacificus* sp. nov. : A, Antennula, arrowheads indicating missing setae; B, Distal margin of labrum, posterior view, C, Maxillula, D, Maxilla.



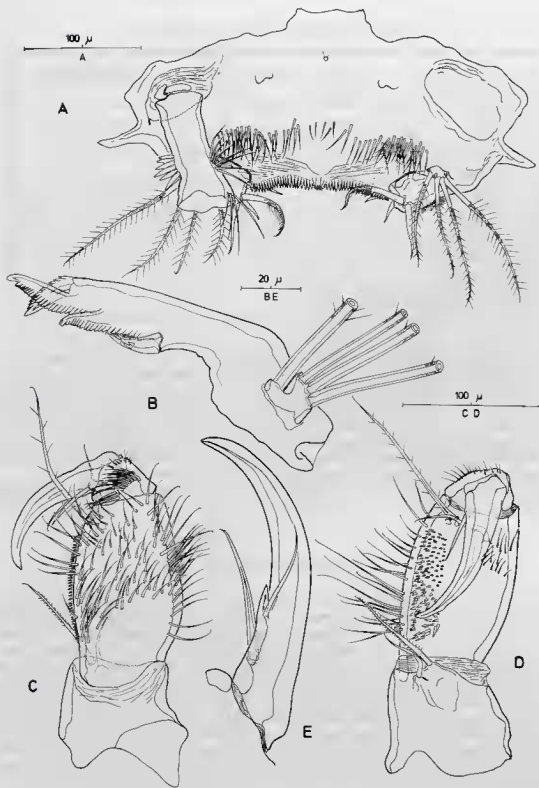


FIG. 4. — *Amphicrossus pacificus* sp. nov. : A, Labrum, anterior view, showing implantation of antennae and orientation of maxillulae and mandibular palp; B, Mandible, posterior view; C, Maxilliped, posterior view; D, Maxilliped, anterior view; E, Maxilliped, claw (second endopod segment).

TABLE I: Salient features of *Amphicrossus* species.

	<i>A. spinulosus</i> Humes, 1989	<i>A. pacificus</i> sp. nov.
Body length of female	2490 $\mu$ m	2260 $\mu$ m
Anal somite	square	1.5 times as long as wide
Antennula, 2nd segment	with 15 setae	with 16 setae
P1, inner spine of basis	not bifid at tip	bifid at tip
P1 exp-3, armature	III 13	III 14
P2 exp-3, armature	III 15	III 14
P3-P4 exp-3, distal inner seta	setiform, plumose	spineform, serrate in distal half
Intercoxal sclerites P1-P3	not ornamented	ornamented
P5 exp, length/width ratio	4/1	5.8/1

Both *Erebonaster protentipes* and *A. spinulosus* were described from deep water habitats (2000-3266 m) where they occur at hydrothermal vents and cold seeps. HUMES (1989) suggested that the genus *Erebonaster* (in its broadest sense) might be widespread in such habitats throughout the world's oceans. The discovery of *A. pacificus* on the New Caledonian shelf constitutes the second record from the southern hemisphere (HUYS & BOXSHALL, 1990) and considerably extends the depth range of the family Erebonasteridae. *A. pacificus* is the second species to be described from the New Caledonian area; examination of additional material collected off New Caledonia during the French BIOGEOGAL expedition revealed a further new genus and species of Erebonasteridae (HUYS & BOXSHALL, 1990). There is no evidence of a possible association of *A. pacificus* with a host.

The removal of *E. spinulosus* to the genus *Amphicrossus* requires a slight amendment of HUMES' (1987) diagnosis of the genus *Erebonaster*.

#### Genus *EREBONASTER* Humes, 1987

DIAGNOSIS. — Erebonasteridae. Body elongate, cephalosome not distinctly wider than fifth pedigerous somite. Body surface smooth. Epimera of 2nd - 4th pedigerous somites expanded posteriorly; somites equal in width. Urosome 5-segmented in female, comprising genital double somite without lateral processes and 3 abdominal somites. Caudal ramus with 6 setae (seta 1 lost). Rostrum prominent, with smooth anterior margin. Antennula 6-segmented; segments slightly ornamented with spinules and setules; aesthetascs on segments III, VI and VII. Antenna with 3 setae on enp-2 and 6 setae/spines on enp-3. Labrum with lateral blunt teeth and median, rounded, spinulose process; anterior face smooth. Gnathobase of mandible with specialised blades; palp with 4 setae. Maxillula without knob-like process. Maxilla with smooth concave margin and 2 setae on distal segment; outer margin of basal segment smooth. Maxilliped unornamented, claw without process/spine near distal seta. Enp-2 P2 without posterior sensory area. Exp-3 P4 with formula II,1,3. Fifth pair of legs lateral, not joined by intercoxal sclerite; extending to anterior margin of anal somite; exopod 3.6 times the length of protopod, with 4 setae.

Sexual dimorphism in genital segmentation, antennula, maxilliped, endopod P2, P5, P6, caudal rami.

TYPE SPECIES. — *E. protentipes* Humes, 1987 (by monotypy).

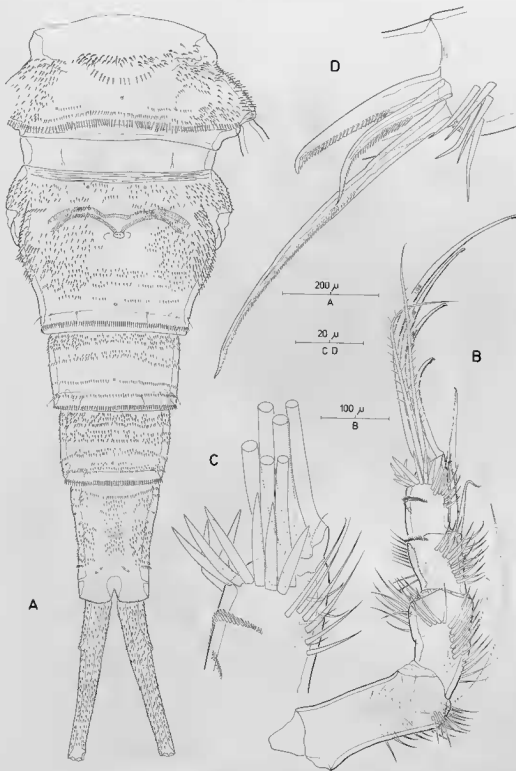


FIG. 5. — *Amphicrossus pacificus* sp. nov. : A, Urosome, ventral view (P5 omitted); B, Antenna, whole view; C, Antenna, detail of distal ornamentation of enp-3; D, Antenna, ornamentation of enp-2.

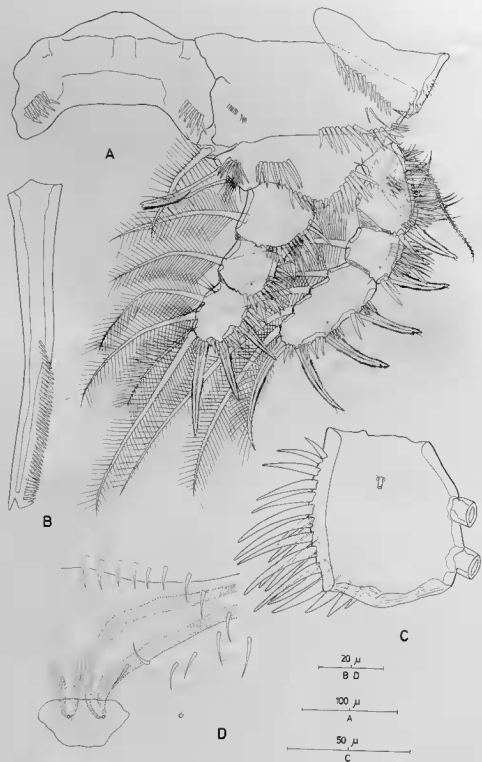


FIG. 6. — *Amphicrossus pacificus* sp. nov. : A, P1, anterior view; B, P1, inner basal spine; C, P2, middle endopod segment, posterior view; D, Copulatory pores.

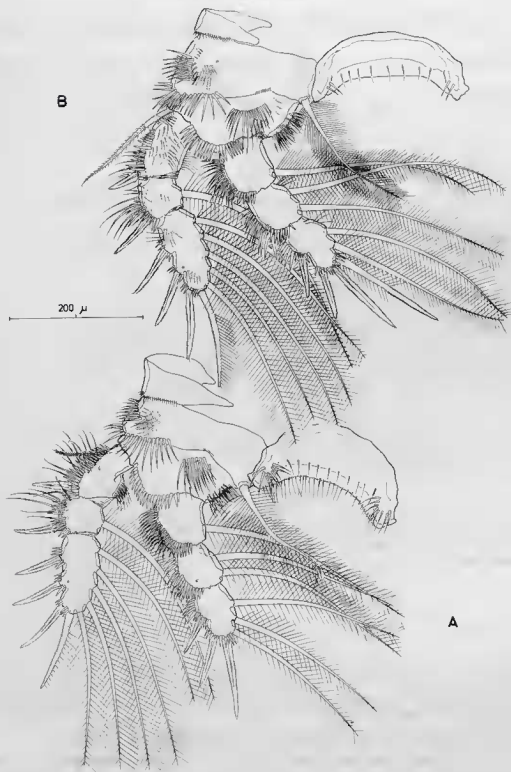


FIG. 7. — *Amphicrossus pacificus* sp. nov. : A, P2, anterior view; B, P3, anterior view.

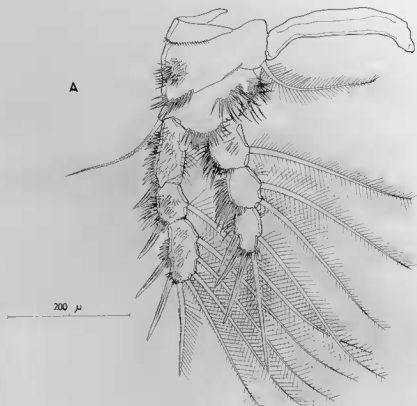


FIG. 8. — *Amphicrossus pacificus* sp. nov. : A, P4, anterior view.

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